HIGH PERFORMANCE EVA GLOVE COLLABORATION: GLOVE INJURY DATA MINING EFFORT

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BACKGROUND: Human hands play a significant role during extravehicular activity (EVA) missions and Neutral Buoyancy Lab (NBL) training events, as they are needed for translating and performing tasks in the weightless environment. It is because of this high frequency usage that hand- and arm-related injuries and discomfort are known to occur during training in the NBL and while conducting EVAs. Hand-related injuries and discomforts have been occurring to crewmembers since the days of Apollo. While there have been numerous engineering changes to the glove design, hand-related issues still persist. The primary objectives of this study are therefore to: 1) document all known EVA glove-related injuries and the circumstances of these incidents, 2) determine likely risk factors, and 3) recommend ergonomic mitigations or design strategies that can be implemented in the current and future glove designs.

METHODS: The investigator team conducted an initial set of literature reviews, data mining of Lifetime Surveillance of Astronaut Health (LSAH) databases, and data distribution analyses to understand the ergonomic issues related to glove-related injuries and discomforts. The investigation focused on the injuries and discomforts of U.S. crewmembers who had worn pressurized suits and experienced glove-related incidents during the 1980 to 2010 time frame, either during training or on-orbit EVA. In addition to data mining of the LSAH database, the other objective of the study was to find complimentary sources of information such as training experience, EVA experience, suit-related sizing data, and hand-arm anthropometric data to be tied to the injury data from LSAH.

RESULTS: Past studies indicated that the hand was the most frequently injured part of the body during both EVA and NBL training [1, 2]. This study effort thus focused primarily on crew training data in the NBL between 2002 and 2010. Of the 87 recorded training incidents, 19 occurred to women and 68 to men. While crew ages ranged from thirties to fifties, the age category most affected was in the forties range. Incident rate calculations (incidents per 100 training runs) revealed that the 2002, 2003, and 2004 time periods registered the highest reported incident rate levels (3.4, 6.1, and 4.1 respectively) when compared to the following years (all ≤ 1.0). In addition to general hand-arm discomfort being the highest reported result from training, specific types of hand injuries or symptoms included erythema, fingernail delamination, abrasions, muscle soreness/fatigue, paresthesia, bruising, blanching, and edema. Specific body locations most affected by hand injuries included the metacarpophalangeal joints, fingernails, finger crotches, fingers in general, interphalangeal joints, and fingertips. Causes of injuries reported in the LSAH data were primarily attributed to the forces that the gloved hands were exposed to due to hand intensive tasks and/or poor glove sizing.

DISCUSSION: Although the age data indicate that most injuries are reported by male crewmembers in their forties, that is also the dominant gender and age range of most EVA crew therefore it is not an unexpected finding. Age and gender analysis will continue as more details on the uninjured population is accrued. While there is a reasonable mechanism to link training quantity to injury, the results were inconsistent and point to the need for a consistent method of suit-related injury screening and documentation. For instance, the high-incident rate levels for the years 2002 to 2004 could be attributed to a comprehensive medical review of crewmembers post-NBL EVA training that occurred from July 19, 2002 to January 16, 2004 [2]. Furthermore, there could have been increased awareness from an investigation at the NBL [3]. These investigations may have temporarily increased the fidelity of reported injuries and discomforts during these dates as compared to surrounding years, when injury signs and symptom were no longer actively being investigated but rather voluntarily reported. Data mining for possible mechanistic factors continues and includes more detailed training timelines, hand anthropometry, and suit sizing information. The limited published data looking at hand–arm anthropometry correlated hand-anthropometry metrics with injuries stemming from glove design and operation [4]. Future work will include further evaluation of body sizing and fit in relation to hand injury incidents.

REFERENCES

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